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Review Article

Recent Studies on Potential Prebiotic Herbs – A Brief Review

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Abstract: The impact of prebiotic on gut microbiota has been studied to varying extents, scarcely little importance is given for its effective utilisation to contribute their nutritional and health benefits to cure or manage diseases. Prebiotics compiles non-digestible fibres which serves as the nutrition for gut microbiota. Gut microbiota release biproducts in the intestine which are beneficial for animal as well as human health with different physiological impacts including diabetes, hypertension, obesity, hormonal brain axis, cancer etc. The present review is a comprehensive and an updated compilation of the available works on different plants with prebiotic properties. Due attention has been taken to cover the on-going trends and recent advances with a perspective vision and their holistic usages and beneficial applications in humans. The current study also shed light on production aspects of prebiotic plants which will enlighten farmers and producers for better economic growth.

Keyword: gut microbiota, nutrition, hypertension, farmers.

INTRODUCTION

"Food be the medication and medicament be the food", the ancient sentence given by Hippocrates to today's health-conscious population. Eli Metchnikoff, the Russian Nobel Prize winner was the primary one to acknowledge the important role of bacteria on the digestive tract of humans (Pandey K. R *et al.,* 2015). The term prebiotics was primarily explained by Glenn Gibson and Marcel Roberfroid in 1995. According to them Prebiotic is defined as a non- palatable food ingredient that usually affects the host by selectively stimulating the expansion and/or action of one or a minimum number of bacteria within the colon, and thus enhance the health of the human body". This definition was constantly used for quite next 15 years. In the year 2008, the sixth conference of the International Scientific Association of Probiotics and Prebiotics (ISAPP) defined "dietary prebiotics" as "a particular fermented ingredient that leads to specific changes within the composition and/or action of the digestive tract microorganisms, thus useful for the health of an individual" (Davani-Davari D *et al.,* 2019).

The micro-organisms that occupy the human GI tract (GI) are involved in the development and performance of a variety of basic physiological activities including digestion, immunity, and maintain homeostasis. In current era lot of studies shows that microorganism present in GI tract play an important role within the development and performance of the central systema nervosum across the selective means, like metabolic, neuro-endocrinal and immune pathways. Oligofructose-enriched inulin prebiotic supplementation in newborn babies with overweight and obesity significantly enhanced premonition of fullness and decreased food utilization in aged persons but not in youngsters. Inflection of microorganisms present in the stomach and biotransformation as a possible strategy for neurological abnormalities and CNS progress (Cerdó T *et al.,* 2017).

In-vivo studies has been done on animal models and human being in relation with various gut diseases or disorders including obesity, diabetes, and inflammatory bowel disease are the diseases which altered microbial communities. Food with low fibre diet and use of antimicrobial agents results in direct modulation of number of bacteria while due to several diseases or disorders indirect modulation is occur (McCabe L *et al.,* 2015).

Yet, there's much to be find out related to prebiotics and the study of their signaling passage that adjacent to the microbiome and its health. The standards of food are extremely important due to many issues such as unwellness, obesity, allergy, cardiovascular diseases, and cancer. The actions of microbial agents available within the channel are important for the betterment of the health status of the subject. They'll be consumed within a variety of raw vegetables and fruit, fermented pickles, or dairy products. The introduction of probiotics, Prebiotics, or symbiotics into the human diet is beneficial for the intestinal microbiota. Prebiotics could also be used as an alternate to probiotics or as extra support for them. However different prebiotics will energize the expansion of various indigenous intestinal microorganisms. Prebiotics has a huge prospective for alteration of the gut microbiota, but this conversion occurs at the extent of individual strains and type of stains and isn't simply predicted the main concern. There is numerous information on the advantageous effects of prebiotics on a person's wellbeing (Markowiak P *et al.*, 2017).

One of the favourable effects of prebiotics is provoking the immune structure of the individual, which can be direct or indirect through the escalating population of advantageous microorganisms or probiotics, mainly *Lactobacilli* and *Bifidobacteria* in the intestine. The main mode of activity of probiotics and prebiotics, by which they can affect the immune system, is altering the expression of cytokines (Shokryazdan P *et al.*, 2017).

Recently various natural herbs and microbial sources have been explored the benefits of plants as prebiotics and probiotics. A number of the novel prebiotics and probiotics are enlisted in Table 1. It is expected that this can remain a vigorous area of research.

Table 1: Properties of an ideal prebiotic (Swennen *et al.*, 2006)

Sr. No	Preferable Aspect	Properties of oligosaccharides
1	More activity at small concentration of dose	*Bifidobacterium* and *Lactobacillus* specifically and effectively metabolized the prebiotics.
2	Minimum side effects	Without generation of gas the useful microorganisms specifically and effectively metabolized.
3	Pertinacity through the colon	Ideally high molecular weight
4	Differ in viscosity	Available in various molecular weights and linkages
5	Desirable storage and processing stability	It contains 1–6 linkages and pyranosyl sugar rings
6	Capable to control microflora modulation	Specifically metabolized by restricted microbial species
7	Differ in sweetness	Due to differ in monosaccharide composition

Types of Prebiotics:

On the basis of definition Prebiotics are classified as follows.

i. Fructans

Inulin and fructooligosaccharide or oligofructose are present in such types of prebiotics. Its structure contains a linear chain of fructose with β (2→1) linkage. They sometimes have glucose units with β (2→1) linkage at endings. DP of inulin is approximate up to 60, on the other side, the DP of FOS is smaller than ten. (Louis P *et al.*, 2016) Previously, a literature study shows that fructans can stimulate lactic acid bacteria specifically. Although, since last years, some studies show that the chain length of fructans is a crucial benchmark to work out which microorganism can ferment them. Thus, some other microorganisms may be stimulated directly or indirectly by fructans (Scott KP *et al.*, 2014).

ii. Galacto-Oligosaccharides

Galacto-oligosaccharides (GOS), the merchandise of lactose extension, are divided into two subcategories viz. (i) the GOS with excess galactose at C3, C4, or C6 and (ii) the GOS produced by lactose through enzymatic trans-glycosylation. The final product of this reaction is especially a combination of tri- to pentasaccharides with galactose in β (1→6), β (1→3), and β(1→4) linkages. Such Type of GOS is known as trans-galacto-oligosaccharides or TOS (Gibson GR *et al.*, 2010; Macfarlane G *et al.*, 2008). GOSs may mostly enhance Bifidobacteria and Lactobacilli. Bifidobacteria in newborn babies have shown high internalization with GOS. Enterobacteria, Bacteroidetes, and Firmicutes also are revived by GOS, but to a smaller extent than Bifidobacteria. (Louis P *et al.*, 2016) There are few GOSs derived from lactulose, the isomer of lactose. These lactulose-derived GOSs also are review as prebiotics (Gibson GR *et al.*, 2010). Apart from these kinds of GOS, more types are supported sucrose extension named raffinose family oligosaccharides (RFO) (Johnson CR *et al.*, 2013; Whelan K *et al.*, 2013).

iii. Starch and Glucose-Derived Oligosaccharides

There is a form of starch that's impervious to the upper gut digestion referred to as resistant starch (RS). RS can foster health by building an elevated level of butyrate; thus, it's been recommended to be sorted out as a prebiotic (Fuentes-Zaragoza E *et al.*, 2011). Several categories of Firmicutes revealed the best assimilation with an excess quantity of RS (Walker AW *et al.*, 2011). An in vitro study verified that RS might be degraded by *Ruminococcus bromii*, and *Bifidobacterium adolescentis*, and also to a smaller amount by *Eubacterium rectale* and *Bacteroides thetaiotaomicron*. Although, within the mixed bacterial and fecal maturation, RS degradation is unfeasible within the absenteeism of R. Bromii (Costabile A *et al.*, 2012). Polydextrose could be a glucose-derived oligosaccharide. It contains glucan with lots of branches and glycosidic linkages. There are several proofs that it can encourage Bifidobacteria, but it's not been committed yet (Yoo HD *et al.,* 2012).

iv. Other Oligosaccharides

Some oligosaccharides are developing from a polysaccharide referred to as pectin. this kind of oligosaccharide is termed pectic oligosaccharide (POS). They've supported the extension of galacturonic acid (homogalacturonan) or rhamnose (rhamnogalacturonan I). The carboxyl group is also substituted with methyl esterification, and also the structure will be acetylated at C2 or C3. Several kinds of sugars (e.g., arabinose, galactose, and xylose) or ferulic acid are linked to the side chains.[18] Their structures differ considerably looking at the sources of POSs (Gullón B *et al.,* 2013).

v. Non-Carbohydrate Oligosaccharides

However, carbohydrates are considered to fulfil the standards of the prebiotics concept, still, some compounds don't seem to come under the categories of carbohydrates but are suggested to be categories as prebiotics, like cocoa-derived flavanols. in vivo and in vitro studies have shown that flavanols can revive as lactic acid bacteria (Tzounis X *et al.,* 2011).

Plants Used as a Prebiotic Activity

1. Chicory:

Cichorium intybus L., commonly referred to as chicory, belonging to the Asteraceae family and geographically it is available in Asia and Europe. All parts of this plant have enormous therapeutic significance because of the existence of a variety of medicinally essential chemical constituents like alkaloids, inulin, sesquiterpene lactones, coumarins, vitamins, chlorophyll pigments, unsaturated sterols, flavonoids, saponins, and tannins. It's outlined that fresh chicory typically contains 68% inulin, 14% sucrose, 5% cellulose, 6% protein, 4% ash, and 3% other chemical constituents, while dried chicory consists of about 98% inulin and 2% other compounds. Leaves of chicory are prominent sources of phenols, vitamins A and C additionally as potassium, calcium, and phosphorus. Furthermore, chicory is rich in cichoric acid may revive the immune system similarly it counteracts inflammation and bacterial infections to a smaller proportion. It has been conventionally used for the management of fever, diarrhoea, jaundice, and gallstones (Abbas ZK *et al.,* 2015).

Mode of Action as Prebiotic Activity of Chicory

Firmicutes/Bacteroidetes ratio and abdomen bacterial groups, like Alloprevotella, Blautia, Alistipes, and Oscillibacter, were found to be regulated by chicory. On another side, CCK and GLP-1 satiety hormones were demonstrated to be considerably improved by chicory in-vitro. Inulin which is present in chicory may be a source of soluble dietary fiber, an archetype prebiotic particularly useful in monogastric nutrition and also used as an efficient supplement (Fouré M *et al.,* 2018).

2. Oats (*Avena sativa*)

The oat (*Avena sativa*), occasionally known as the common oat, could be a class of cereal grain developed for its seed. While oats are used in our day-to-day life as food nutrition. As oatmeal and rolled oats, one amongst the foremost general use as livestock feed (Miraj S *et al.,* 2016). Whole oat contains a huge quantity of essential nutrients like soluble fibers, proteins, unsaturated fatty acids, vitamins, minerals, and other phytochemicals. In the leaves and straw in soluble form as esters of silicic acid contains 17.1% protein, 67.9% carbohydrates, 8.6% fat, 15-22% dietary fiber, 10.4% β-glucan, 1.3 mg niacin, 171 mg magnesium, 0.17 mg copper, 441 mg potassium and α- tocopherol less than 0.5 mg. Silicon dioxide (2%) in every 100 grams of oats. Although, it is also rich in body-building nutrition such as silicon, manganese, zinc, calcium, phosphorus, and vitamins A, B1, B2, and E. It had been used as cardiac and nerve tonic, for spermatorrhoea, palpitation, sleeplessness, antispasmodic, for diarrhoea, dysentery, and colitis. It is used as a thymoleptic, antidepressant, and externally as an emollient (Al-Snafi AE *et al.,* 2015).

Mode of Action as Prebiotic Activity of Oats

Depending upon the constituents, viscosity, and concentration of oats NSP in fermentation medium it has been given that *Bacillus licheniformis* pre-digests oat NSP, degrades the high viscosity of oat β-glucan, and makes hemicellulose easier to access for another bacterial microorganism. Due to the fermentation, *B. licheniformis* produces lactic and succinic acids, they can be utilized for other bacteria for cross-feeding and SCFA production (Sargautiene V *et al.,* 2018; Perrelli A *et al.,* 2018).

3. Soyabean

Soyabeans are the good-natured dried seeds of the plant *Glycine soja*, belonging to the family Leguminosae or Fabaceae. It is extremely used as a nutraceutical. However, the geographical indication of this plant is Southeast Asia, United States. Argentina, Brazil, China, and India. It contains a high amount of 35% carbohydrates (disaccharide sucrose, the trisaccharide raffinose, galactose, tetrasaccharide stachyose), fats, vitamins, and minerals (calcium, iron, and potassium) with high quality of proteins and amino acids near about 40% (which contain 1-3mg. of isoflavones per gram of soy protein) and 5% ash (non-aqueous, metal oxides). It is also an additional resource of lecithin or phospholipid, isoflavones including genistein, daidzein, and glycitein, saponins, phytosterols (Talele HV *et al.,* 2012).

Mode of Action as Prebiotic Activity of Soyabean:

The report suggests that stomachic administration of SBOSs at a dose of 4.0 g/kg BW−1 enhances the numbers of useful intestinal microbes and increasing the immunity power of mice. Hence, we use it as a source of prebiotics (Ma Y *et al.,* 2017; Le B *et* *al.*, 2020). Feeding of it decreases the incidence of AOM-induced colon tumours with implications for the food industry in the food-product development (Gourineni VP *et al.,* 2011).

4. Garlic

Garlic (*Allium sativum* L.; Family: Amaryllidaceae) is an aromatic nonwoody flavour and one among the elderly authenticated and most significant herbs that are used from prehistoric times as conventional drugs. Allicin [S-(2-propenyl)-2-propene-1-sulfinothioate] and fructan are the principle chemical constituent present in garlic. The species of these drugs especially their chemical constituents are useful for the treatment of life-threatening diseases like cancer, diabetes, and cardiovascular diseases, cold, influenza and snake bites, lung disorders, respiratory disease, stomach disorders. It enhances the immune system which is helpful for protection for various antimicrobial infections such as antifungals, anti-aging. It is also used in cooking (El-Saber Batiha G *et al.,* 2020).

Mode of Action as Prebiotic Activity

The most essential chemical constituent present in garlic is fructans which is responsible for the prebiotic activity. In literature, it is studied and shows that log CFUs of both Bacteroides (GF A 6.96, GF B 7.15) and Bifidobacteria (GF A 7.74, GF B 7.74) grown within the GF cultures at 24 hours were significantly more than those at 0 h (Bacteroides 4.93, Bifidobacteria 4.78) ($P < 0.05$). During this study, GFs were found to selectively reviving the development of beneficial Bifidobacteria from human fecal microflora (Zhang N *et al.*, 2013). It may enhance the development of L. acidophilus bacteria with the minimum concentration of 4% being the foremost effective ($p<0.05$) (Sunu P *et al.*, 2019). Finally, we can say that prebiotic treatment increases the growth of Lactobacillus acidophilus especially at 24 hr. fructooligosaccharide which is present in garlic, also when propagated in MRS without prebiotic treatment (Kubba MA *et al.,* 2021).

5. Jerusalem artichoke

Jerusalem artichoke is a perpetual herb of *Helianthus tuberosus L*, belonging to the family Asteraceae. It is tolerated to biotic stress such as pests and diseases due to this important property of this plant the cultivation becomes the various benefits. The development of this plant is carried out in salt-affected soil, sandy soil, and marginal lands without any fertilization. Furthermore, it may grow against dry environments, low and elevated temperatures conditions. The presence of a huge amount of carbohydrates such as inulin, fructose, protein, nutrients, and vitamins in the part of the tuber of the plant has high nutritional value. In the whole plant or its parts such as tubers, leaves, or flowers it contains sesquiterpene lactones, phenolic acids, flavone glucosides (kaempferol 3-O-glucoside and quercetin 7-O-glucoside), chlorophylls, and carotenoids as a chemical constituent which is explained in various literature. These chemical constituents can be utilised for anticancer, antidiabetic, antioxidant, antifungal, and antimicrobial purposes (Kaszás L *et al.,* 2020).

Mode of Action as Prebiotic Activity of Jerusalem artichoke

The prebiotic activity of this plant is due to the high contents of inulin-rich carbohydrates (Rubel, 2014). The JA extract enhances the development of L. plantarum, L. acidophilus, B. longum, and B. Breve at an elevated concentration of 2%. At 12 hours incubation period the 2% concentration shows the growth-promoting effect of this extract (Rattanakiat S *et al.*, 2020; Ali MS *et al.*, 2016).

6. Asparagus root (Tianmendong)

It consists of dried roots of *Asparagus cochinchinensis*. It cotains asparacosin A, and asparacosin B as important phytoconstituents, furostanosides, methylprotodioscin and pseudoprotodioscin. In aq. Extract oligofurostanoside 3-O-[α-L-rhamnopyranosyl-(1→4)-β-D-glucopyranosyl]-26-O-(β-D-glucopyranosyl)-(25R)-furosta-5,20-diene,-3β,26-diol is isolated and studied. This plant is cytotoxicity properties (Negi JS *et al.,* 2010; Liang ZZ *et al.,* 1988).

Mode of Action as Prebiotic of Asparagus root:

The prebiotic activity was carried out by in vitro fermentation with human fecal cultures. It shows that it was digested by gut microbiota. The results showed that ACNP was digested by gut microbiota, while the pH value within the fecal culture of ACNP was greatly decreased, and total short-chain fatty acids, acetic, propionic, i-valeric, and n-valeric acids were significantly increased. Furthermore, it is regulated the fecal microbiota composition by reviving the development of Prevotella, Megamonas, and Bifidobacterium while depleting Haemophilus (Sun Q *et al.,* 2020).

7. Wheat:

It consists of shoots of *Triticum aestivum* belonging to the family Gramineae and is routinely known as wheatgrass. Triticum may be a genus of annual and biennial grasses, yielding various kinds of wheat, native to southwest Asia and the Mediterranean region. Polysaccharides-Glucans, oil resorcinols (0.1 – 0.2%). The principal carotenoid pigment ofa (2%), Phospholipids (1%), Glycolipids (0.5%): particularly acyldigalactosylglycerols, Steroids (0.3%): sterol esters, Proteins (20%), Lignin, Alkyl – dihydroxycarotene are the chemical constituents present in this plant. It is used for the treatment of cancer, acute diarrhoea, antifungal, and antioxidants (Kumar *et al.,* 2011).

Mode of Action as Prebiotic Activity of Wheat

According to the literature, the two important chemical constituents viz. wheat AX and barley β-glucan contribute the prebiotic activity. It also suggests that food ingredients present in the plant are also of great interest as prebiotic activity (Harris S *et al.*, 2019; Madhukumar MS *et al.*, 2010).

8. Leek:

Leek is a folk medicine of *Allium ampeloprasum* belonging to the family Amaryllidaceae. Under the morphological characteristics, it has a characteristic taste, leek produces a long cylinder of bundled leaf sheaths and other morphological features, It becomes it has made it an admirable natural drug. The chemical constituents present in this plant is dimethyl disulfide, methyl propenyl disulfide, propyl propenyl disulfide, dimethyl trisulfide, methyl propyl trisulfide, methyl propenyl trisulfide, S-methyl cysteine sulfoxide, S-propyl cysteine sulfoxide, S-propenyl cysteine sulfoxide, N-(γ-glutamyl)-S-(E-1-propenyl) cysteine. It is used as like antidiabetic, hypolipidaemic, antimicrobial, radical scavenging and anti-inflammatory activity (Dey P *et al.*, 2015).

Mode of Action as Prebiotic Activity

With the help of chemical constituents present in these plants, it shows that it revives the prebiotic bacterial microorganism especially *Lactobacillus acidophilus*. In the literature, it is given that bacterial count is more without plant and it is less with the plant (Swamy KR *et al.*, 2006).

9. Recently Studies Prebiotic Herbs:

Here in the following table some of the natural plants which are used in our day-to-day life are explained with their mode of action given the literature is explained.

Sr. No.	Name of Herb	Biological Name	Part Used	Mode of Action Reported	Reference
1	Orange	*Citrus sinensis*	Peel	This plant improves the bifidobacteria and lactobacilli content which results in enhances the proportion among the joint counts of both genera.	(Gomez *et al.*, 2014)
2	Apple bagasse	*Malus domestica*var	Fruit	It formed AGCC by fermentation of colonic bacteria.	(de Souza *et al.*, 2017)
3	Banana	*Musa acuminata, Musa balbisiana, Musa sapientum*	Peel	Prebiotic activity of banana is totally depends upon the carbohydrates content in the plant.	(Powthong *et al.*, 2020)
4	Mulberry	*Morus nigra L.*	Whole plant	In the prebiotic we can utilize the natural antioxidant oligosaccharide EMOS-1a which is present in this plant.	(Li E *et al.*, 2019)
5	Balloon flower	*Platycodon grandiflorus*	roots	In the literature, it is mentioned that this plant is having a natura property as prebiotics.	Pang DJ *et al.*, (2019)
6	lemon	*Citrus limon*	Peel	This plant shows prebiotic activity due to presence of pectin-derived oligosaccharides.	Míguez B *et al.*, (2020)
7	Buluh beting	*Gigantochloa levis*	Shoots	Due to enhancement in the growth of *B. animalis, B. longum* and *L. acidophilus*, the shoots shows the prebiotic activity.	Azmi AF *et al.*, (2012)
8	Violet Bamboo	*Phyllostachys praecox*	Shoots	Prebiotic property of this plant is depend on the polysaccharides and also enhance the number *Bifidobacterium adolescentis* and *Bifidobacterium bifidum which forms the* organic acids.	He S *et al.*, (2016)
9	Potato	*Solanum tuberosum*	Peel	It enhances the endurance bacterial strains to gastro-intestinal tension.	(Thakur K *et al.*, 2018)

CONCLUSION

Prebiotics has captured tension since last decade were discussed in the current review. Insoluble and unobservable food ingredients like fibres, polysaccharide, few lipids serve as source for the nutrition for the gut microbiota which helps absorbing them for health benefits. Chicory, soyabean, wheat, oats, leek, garlic, asparagus, artichoke are studies largely by different researchers to analyse their health benefit through gut microbiome rout. The proofs are compiled in the present revives which explain activities of these plants like hypolipidemic, antihypertensive, antimicrobial, antifungal, antioxidant, laxative etc. Recently many plants with variable proportions of prebiotic content are researched like banana peel, orange peel, seeds of different berries, bamboos etc. Prebiotic composition is spread in all parts of the plants like seeds, fruits, fruit peels, leaves, roots, stems, barks etc. Therefore, more research is expected in the toxicology and potency of the nutritive therapeutic value of these prebiotic plants.

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